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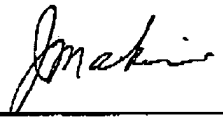
Signed this 6th day of October, 2004



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[List of Attached Documents]

[Article]	Specification	1 copy
[Article]	Drawings	1 copy
[Article]	Abstract of the Description	1 copy

[Confirmed Specification] required

[Designation of Document] Specification

[Title of the Invention] SOLID LUBRICANT AND SLIDING MEMBERS

[Claims]

[Claim 1] A solid lubricant comprising a suspension having a powder of RBC (rice bran ceramics) suspended in a liquid resin, the suspension being capable of forming a dry film upon application and drying.

[Claim 2] The solid lubricant according to claim 1, wherein the RBC is in the proportion of from 22 to 74% by weight.

[Claim 3] The solid lubricant according to claim 1 or 2, wherein the RBC has a mean particle diameter not exceeding 5 microns.

[Claim 4] The solid lubricant according to any of claims 1 to 3, wherein the liquid resin is an acrylsilicone resin.

[Claim 5] A sliding member having a sliding surface covered with a dry film formed by applying the solid lubricant according to any of claims 1 to 4.

[Detailed Description of the Invention]

[0001]

[Technical Field to Which the Invention Belongs]

This invention relates to a solid lubricant and a sliding member having a sliding surface covered with a

dry film formed by applying a solid lubricant.

[0002]

[Prior Art]

There has hitherto been developed a solid lubricant prepared by using molybdenum disulfide (MoS_2), a polytetrafluoroethylene resin (PTFE), etc. as a filler and a polyimide, polyamideimide or epoxy resin, etc. as a binder, as disclosed, for example, in Patent Literature 1 or 2.

[0003]

There has also been developed a hard porous carbonaceous material made by burning and carbonizing in a nitrogen gas atmosphere a material prepared by mixing defatted rice bran with a phenol resin, and called RBC (rice bran ceramics), as disclosed in Patent Literature 3.

[0004]

[Patent Literature 1] JP-B-63-5640

[Patent Literature 2] Patent No. 2,577,416

[Patent Literature 3] JP-A-10-101453

[0005]

[Problems to Be Solved by the Invention]

The solid lubricant is, however, primarily aimed at a reduction of frictional force and an improved scoring resistance in the initial stage. Even if it may give good

initial sliding properties, the wear of the solid lubricant occurring with the passage of time causes the base surface to be exposed and eventually undergo scoring (roughening of the sliding surface) or seizure.

The performance (wear resistance, coefficient of friction, etc.) of the solid lubricant differs markedly with the properties of the constituents of the filler and binder particularly in an oil-free environment. Consideration is, therefore, required for the selection of the constituents of the filler and binder in order to improve the performance of the solid lubricant.

[0006]

It is an object of this invention to employ RBC as a filler for a solid lubricant and provide a solid lubricant giving good wear resistance and sliding properties.

[0007]

[Means for Solving the Problems]

For solving the above problems, the solid lubricant as the invention according to claim 1 is characterized by comprising a suspension having a powder of RBC (rice bran ceramics) suspended in a liquid resin, the suspension being capable of forming a dry film upon application and drying.

[0008]

The invention according to claim 1 enables the solid lubricant to form upon drying a dry film having better wear resistance and sliding properties than any known solid lubricant containing molybdenum disulfide (MoS_2), a polytetrafluoroethylene resin (PTFE), etc. as a filler.

The presence of RBC as a kind of carbonaceous material makes it possible to form a dry film having electrical conductivity.

[0009]

The invention according to claim 2 is characterized in that the RBC in the solid lubricant according to claim 1 is in the proportion of from 22 to 74% by weight.

[0010]

The invention according to claim 2 provides the same advantages as the invention according to claim 1 and moreover enables the solid lubricant to form a dry film having still better wear resistance and sliding properties upon drying.

[0011]

The invention according to claim 3 is characterized in that the RBC in the solid lubricant according to claim 1 or 2 has a mean particle diameter not exceeding 5 microns.

[0012]

The invention according to claim 3 provides the same

advantages as the invention according to claim 1 or 2 and moreover enables the solid lubricant to form upon hardening a dry film having a surface of improved smoothness giving still better sliding properties, since the RBC has a mean particle diameter not exceeding 5 microns.

[0013]

The invention according to claim 4 is characterized in that the liquid resin in the solid lubricant according to any of claims 1 to 3 is an acrylsilicone resin.

[0014]

The invention according to claim 4 provides the same advantages as the invention according to any of claims 1 to 3 and moreover enables the solid lubricant to form a dry film giving good wear resistance and sliding properties easily upon application and drying on an object.

This material can form a sliding surface having good wear resistance and sliding properties without calling for any special heat treatment only upon application to any portion as required.

[0015]

The sliding member as the invention according to claim 5 is characterized by having a sliding surface covered with a dry film formed by applying the solid

lubricant according to any of claims 1 to 4.

[0016]

The invention according o claim 5 gives the sliding member a sliding surface having good wear resistance and sliding properties. The sliding member having a sliding surface of good wear resistance and sliding properties is easy to make only if the solid lubricant is applied to its sliding surface. Moreover, it is possible to use a metallic material, or any of various resins including an ABS resin for the main body of the sliding member.

[0017]

[Mode of Carrying Out the Invention]

Description will now be made of solid lubricants and sliding members embodying this invention with reference to drawings.

[0018]

Test specimens for sliding members (Test Specimens 1 to 3) were prepared by preparing three kinds of solid lubricants each comprising a suspension containing 22%, 60% or 74% by weight of RBC (a powder having a particle diameter not exceeding 5 microns) in acrylsilicone (product of Chisso Corporation designated as SCT-8102), applying each lubricant onto the sliding surface (having an area of 50 mm^2) of a sliding member made of an aluminum alloy to form a thickness of 10 to 100 microns and drying

it at 100°C for 0.5 hour to form a dry film.

[0019]

The coated surfaces of the three test specimens were photographed through an electron microscope. The RBC particles having a diameter not exceeding 5 microns were confirmed on all of Test Specimens 1 to 3.

The hardened solid lubricant on Test Specimen 1 having an RBC proportion of 22% by weight was found to contain the RBC particles scattered in the acrylsilicone. The hardened solid lubricant surfaces on Test Specimens 2 and 3 having RBC proportions of 60 and 74%, respectively, by weight were found covered substantially uniformly with the RBC particles.

[0020]

Friction tests were conducted on the three test specimens by employing a rigid pendulum type physical property testing machine, PRT3000W of A & D Co., Ltd., at an oscillating cycle of 0.75 second and a temperature varying in the range of 30°C to 350°C (400°C) under oil-free conditions. The results are shown below.

[0021]

Test Specimen 1 maintained a substantially equal logarithmic decrement of friction in the vicinity of 0.02 in the range of 30°C to 350°C as shown in Fig. 1, and was thus ascertained as being of good sliding properties.

Test Specimen 2 tested in the range of 30°C to 400°C maintained a logarithmic decrement of about 0.03 in the vicinity of 100°C to 150°C and about 0.01 in any other temperature range as shown in Fig. 2, and was thus ascertained as being comparable to Test Specimen 1 in sliding properties.

Test Specimen 3 tested in the range of 30°C to 300°C maintained a logarithmic decrement of about 0.08 in the vicinity of 75°C and 210°C and about 0.01 to 0.06 in any other temperature range as shown in Fig. 3, and was found non-uniform in sliding properties as compared with Test Specimens 1 and 2.

[0022]

The distribution of RBC in the surface of the dry film formed upon drying of the applied solid lubricant and the sliding properties of the sliding surface covered with the dry film as discussed above taught that the best sliding properties could be obtained when the solid lubricant had an RBC proportion of about 60% by weight.

[0023]

Then, a test specimen (Test Specimen 4) was prepared by preparing a solid lubricant comprising a suspension containing 60% by weight of RBC (a powder having a particle diameter not exceeding 5 microns) in acryl-silicone (product of Chisso Corporation designated as

SCT-8102), applying it onto the end surface (having an area of 50 mm^2) of a solid cylindrical pin made of an aluminum alloy to form a thickness of 10 to 100 microns and drying it at 100°C for 0.5 hour to form a dry film.

For the sake of comparison, a test specimen (Test Specimen 5) was prepared by applying to the end surface of a pin as described above a commercial solid lubricant comprising a polyamideimide with molybdenum disulfide (MoS_2) and a polytetrafluoroethylene resin (PTFE).

[0024]

A frictional wear test was conducted on those two test specimens by employing a pin-on-disk type frictional wear testing machine at a surface pressure of 0.8 MPa and a velocity of 0.314 m/s (with a rotating radius of 20 mm and a rotating speed of 150 rpm) against a carburized SCM415 material under oil-free conditions. The results are shown below.

[0025]

Test Specimen 4 showed a steady frictional force in the range of 11 to 15 N throughout a test time of 3216 minutes and was ascertained as being free from any scoring. Test Specimen 5 showed a frictional force varying in the range of 12 to 15 N during the beginning of the test, but the test was discontinued as scoring was found on the dry film 198 minutes after it had been started.

[0026]

Thus, it was confirmed that Test Specimen 4 having the dry film formed from the solid lubricant according to this invention had a wear resistance more than 16 times higher than Test Specimen 5 having the dry film formed from the known solid lubricant.

[0027]

The forms of embodiment have been described by referring to sliding members as test specimens and more specifically, the uses as described below will be possible. A shaft 2 (sliding member) is supported by a bearing 1 axially slidably, as shown in Fig. 4(a), or a shaft 4 (sliding member) is supported by a bearing 3 slidably in the direction of its rotation, as shown in Fig. 4(b), and the shaft 2 or 4 has on its surface making sliding contact with the bearing 1 or 3 a sliding surface covered with a dry film 5 formed by applying and drying a solid lubricant containing a powder of RBC. Alternatively, the solid lubricant may be applied onto the surface of the bearing 1 or 3.

[0028]

The solid lubricant and sliding member according to this invention are not limited to the forms of its embodiment as described above, but various improvements and design changes may be made without departing from

the concept of this invention. According to the forms of embodiment described above, for example, SCT-8102 of Chisso Corporation has been employed as the binder, but it is also possible to use any other acrylsilicone resin, such as ZEMLAC (registered trademark) of Kanegafuchi Chemical Industrial Co., Ltd., after taking use and cost of production into account. Moreover, it is also possible to use a resin other than any acrylsilicone resin, for example, a polyimide, polyamideimide or epoxy resin, as the binder. It is also possible to add a curing agent if required for achieving improved mechanical properties and a reduction of friction.

The solid lubricant of this invention can be treated like a paint, and can, therefore, be used for various purposes in addition to coating the surface of a sliding member for improving its wear resistance and sliding properties. For example, it may be used to coat a die, tool or material to be worked in cold plastic working (such as wire drawing, steel rod or pipe drawing, pipe or sheet metal stamping, pipe or sheet metal rolling, ring and header), the inner surface of a mold as a release agent in molding, or a tool or material to be worked in cutting.

Although the forms of embodiment have been described as forming a dry film by drying at 100°C for 0.5

hour, the drying temperature and time are widely variable in view of productivity, production equipment, etc. A high temperature and a short drying time may be employed if quick drying is desired, and if no temperature elevating equipment is available, drying may be allowed to last for several days at an ordinary room temperature.

It is, of course, possible to alter other specific structural details, too, as they are considered adequate.

[0029]

[Advantages of the Invention]

The invention according to claim 1 enables the solid lubricant to form upon drying a dry film having better wear resistance and sliding properties than any known solid lubricant containing molybdenum disulfide (MoS_2), a polytetrafluoroethylene resin (PTFE), etc. as a filler.

The presence of RBC as a kind of carbonaceous material makes it possible to form a dry film having electrical conductivity.

[0030]

The invention according to claim 2 provides the same advantages as the invention according to claim 1 and moreover enables the solid lubricant to form a dry film having still better wear resistance and sliding properties upon drying.

[0031]

The invention according to claim 3 provides the same advantages as the invention according to claim 1 or 2 and moreover enables the solid lubricant to form upon hardening a dry film having a surface of improved smoothness giving still better sliding properties, since the RBC has a mean particle diameter not exceeding 5 microns.

[0032]

The invention according to claim 4 provides the same advantages as the invention according to any of claims 1 to 3 and moreover enables the solid lubricant to form a dry film giving good wear resistance and sliding properties easily upon application and drying on an object.

This material can form a sliding surface having good wear resistance and sliding properties without calling for any special heat treatment only upon application to any portion as required.

[0033]

The invention according o claim 5 gives the sliding member a sliding surface having good wear resistance and sliding properties. The sliding member having a sliding surface of good wear resistance and sliding properties is easy to make only if the solid lubricant is applied to its sliding surface. Moreover, it is possible to use

a metallic material, or any of various resins including an ABS resin for the main body of the sliding member.

[Brief Description of the Drawings]

[Fig. 1] is a graph showing the sliding properties of a solid lubricant and a sliding member embodying this invention.

[Fig. 2] is a graph showing the sliding properties of a solid lubricant and a sliding member according to another embodiment of this invention.

[Fig. 3] is a graph showing the sliding properties of a solid lubricant and a sliding member according to still another embodiment of this invention.

[Fig. 4] shows specific examples of application of this invention and includes (a) a sectional view showing an example of arrangement in which a shaft is supported by a bearing axially slidably, (b) a sectional view showing an example of arrangement in which a shaft is supported by a bearing slidably in the direction of rotation, and (c) a sectional view showing an example of arrangement in which a film is formed on the sliding surface of a shaft by applying and drying the solid lubricant according to this invention.

[Explanation of Reference Numerals]

1 - Bearing

2 - Shaft (sliding member)

3 - Bearing

4 - Shaft (sliding member)

5 - Dry film

[Designation of Document] Abstract

[Abstract]

[Object] To employ RBC (rice bran ceramics) as a filler for a solid lubricant and provide a solid lubricant giving good wear resistance and sliding properties.

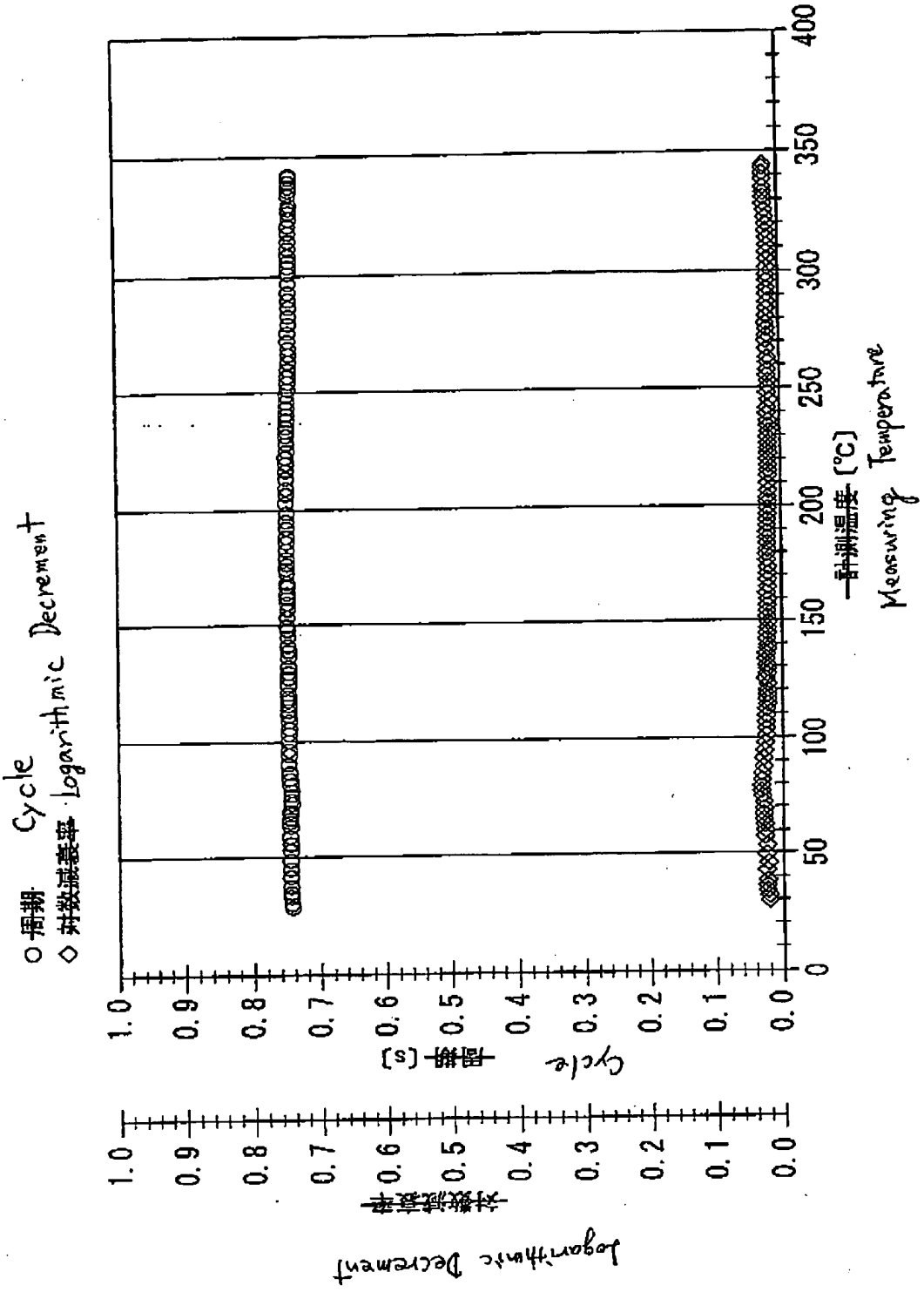
[Solution] A suspension having a powder of RBC (rice bran ceramics) suspended in a liquid resin is used as a solid lubricant. The solid lubricant preferably has an RBC proportion of 22 to 74% by weight. The RBC preferably has a mean particle diameter not exceeding 5 microns. An acrylsilicone resin is preferably used as the liquid resin used as the binder. The solid lubricant is applied onto the sliding surface of a sliding member made of a metal, any of various resins, etc. to form a dry film thereon.

[Selected Figure] None.

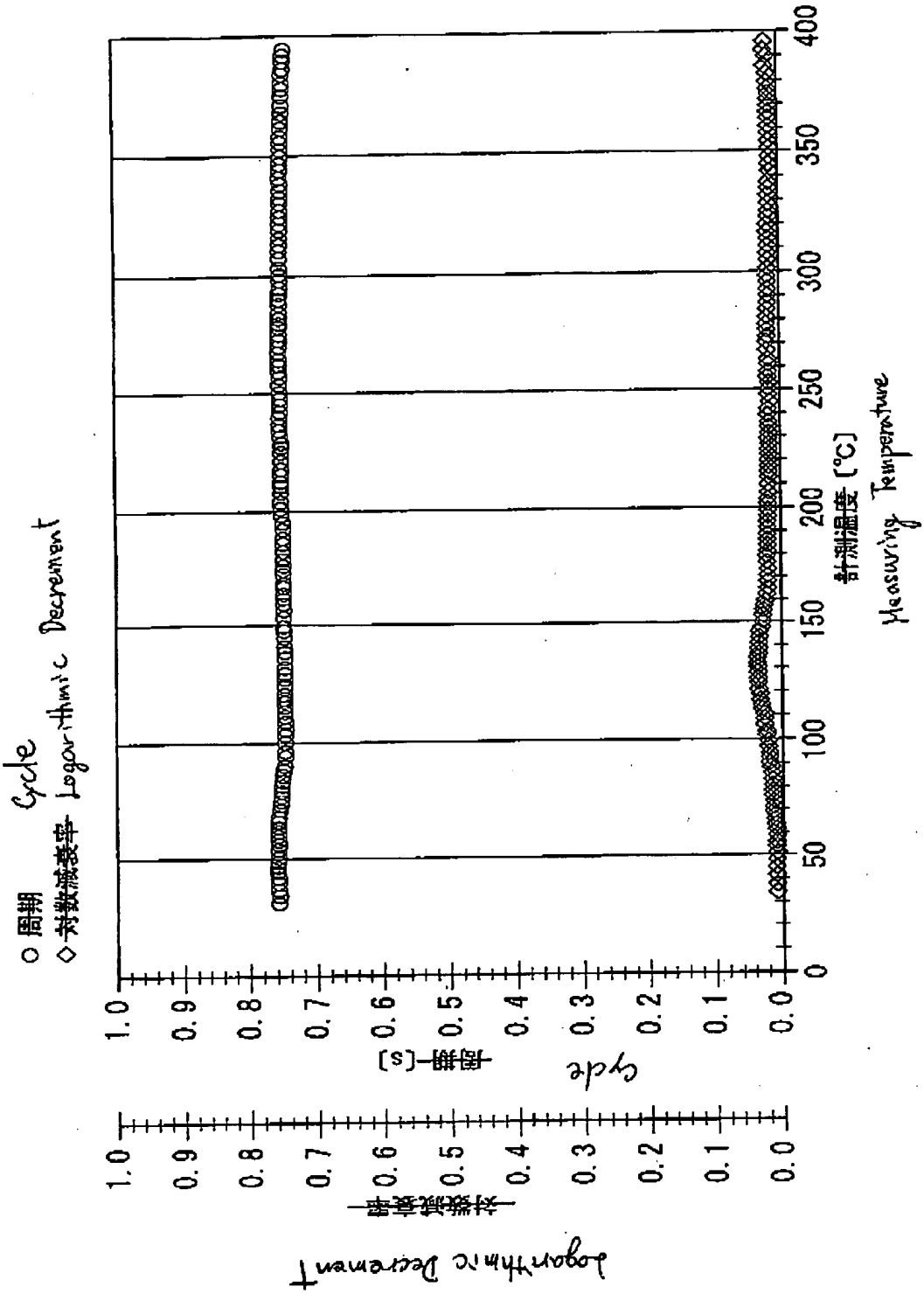
document ~~【書類名】 図面~~ drawing

~~【図1】~~

fig. 1



~~図2~~ Fig. 2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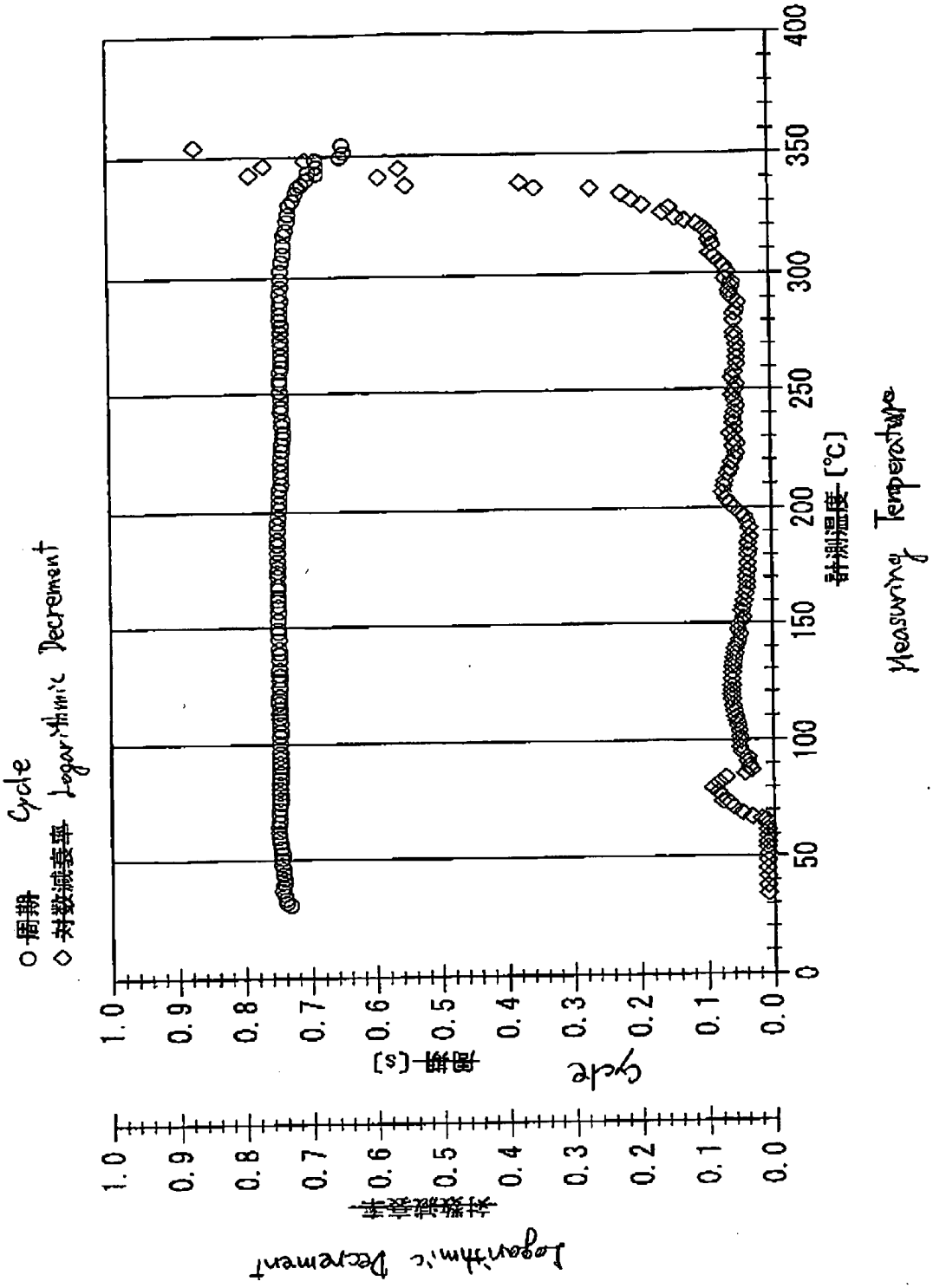
◇ 対数減衰率 Logarithmic Decrement
周期 [s]
Cycle
対数減衰率
Logarithmic Decrement
計測温度 [°C]
Measuring Temperature
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
50
100
150
200
250
300
350
400

~~【図3】~~ Fig. 3


○ 周期 Cycle
◇ 対数減衰率 Logarithmic Decrement
周期 [s]
Cycle
対数減衰率
Logarithmic Decrement
計測温度 [°C]
Measuring Temperature
0
50
100
150
200
250
300
350
400
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

~~【図4】~~ Fig. 4